Original Research Paper

Volume - 11 | Issue - 09 | September - 2021 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Dental Science

RESIN ADHESION AND ENDODONTICS

Dr Seema Yadav Department of Conservative Dentistry & Endodontic Maulana Azad Institute of Dental Sciences New Delhi

ABSTRACT The restoration of endodontically treated teeth using resin adhesive materials has become popular in clinical practice. Improvement in physical and mechanical properties of resin composites has resulted in preservation of remaining tooth structure. The quality and stability of adhesive interface in enamel and dentin plays an important role in the long term clinical success of composite restoration and endodontic outcomes. The bonding of resin composites to root filled tooth presents special problems. The decision making for resin adhesives with tooth substrate, need for operative procedures and materials are discussed in relation with root canal treated teeth.

KEYWORDS : resin adhesives,endodontically treated teeth

The endodontically treated teeth are different from vital teeth. Nevertheless pulpless dentin requires the same care as a vital teeth during adhesive procedures. The primary goal of restoring root filled teeth is to prevent coronal leakage and its subsequent harmful consequences. Resin adhesives have been widely used in the restoration of endodontically treated tooth. These restorations can be extracoronal, intracoronal and intraradicular restoration. The resin adhesives have shown promising results in clinical situations. This review paper will examine the factors associated with effectiveness of bonding of resin adhesives to endodontically treated tooth.

Tooth related Factors

1. Enamel

Enamel is present either along the margins of access preparations or along the finish line for extra coronal restorations of root filled teeth[1,2]. The bonding of resin to etched enamel is strong and durable. The well establish enamel bond will protect the underlying dentin bond which is less predictable. Nevertheless care should be taken that etched enamel may not be contaminated with blood, saliva or moisture. The contaminated etched enamel results in marginal staining of the restoration and its subsequent failure[1].

2. Coronal Dentin

The regional differences in the intertubular dentin and dentinal tubule direction may have an impact on the effectiveness of the resin adhesives[3]. The bonding to deep dentin is more difficult than superficial dentin[3,4]. The decreased intertubular dentin and wider dentinal tubules of the deep dentin results in lower bond strengths than the superficial dentin[3,5].

3. Pulp chamber Dentin

There are regional differences in pulp chamber dentin and coronal dentin which has resulted in difficult bonding of pulp chamber dentin compared to coronal dentin. The bonding to pulp chamber dentin is difficult due to many reasons. First, there is presence of irregular secondary dentin, predentin, accessory canals and sclerotic dentin[6,7]. Second, the dentin showed increased number of dentinal tubules with wider diameters and decreased intertubular dentin[8]. Third, there is high C-factor, which results in increased polymerization shrinkage stress and microleakage of the adhesive interface[9]. Finally, various irrigants, medicaments and temporary filling materials used during root canal treatment affects the dentinal surface[9].

4. Root canal Dentin

There are various challenges involved in adhesion to root dentin. Presence of humidity, decreased intertubular dentin , altered dentin surface during root canal treatment and unfavourable C factor in the root dentin makes bonding demanding. The presence of contaminants on the dentin surface also contributes to ineffective bonding [10].The predentin present in the radicular dentin is removed during endodontic treatment using instruments or burs[11,12]. Following endodontic therapy ,the dehydration of dentin results in brittleness[13].

5. Caries-affected dentin

The caries-affected dentin is different in structure and in chemical as well as physical characteristics from normal dentin [14]. Caries affected dentin has reduced mineral content, changes in the dentin collagen structure and non collagenous protein content [15].The application of etchants on such dentin forms deep demineralized zone. The smear layer is thick and irregular with more organic contents. The resin monomers unable to reach to the base of the exposed collagen matrix and produce thick hybrid layer which is poorly infiltrated with resin monomers[1].

The dentin contains substances that results in poor polymerization of adhesive monomers [16]. The mineral deposits in dentinal tubules are highly acid resistance and restricts resin monomer infiltration and resin tag formation. The inadequate resin monomer penetration leads to lower bond strength and does not provide seal at the resin–dentin interface [17].

6. Noncarious sclerotic dentin

Sclerotic dentine is physiologically and pathologically altered dentin. It has shown sclerotic casts in the dentinal tubules , acid-resistant surface hyper mineralised layer, and a bacterial surface layer [18].It act barriers for resin monomer infiltration[19].

The sclerotic dentine is frequently observed in cervical noncarious lesions of the tooth. The dentin varies along the occlusal, gingival, and the base of wedge-shaped lesion. The variation resulted wide difference in hybrid layer and resin tag formation. There are areas with minimal or no resin tag formation. These vulnerable areas has contributed to adhesive failures [19]. Moreover sclerotic dentin produces reduced bond strength than normal dentin.

Procedure related Factors

1. Enhanced illumination and magnification

The illumination and magnification helps in meticulous examination of carious and healthy structures. It can detect cracks or fractures. It helps in elimination of diseased tooth structure without removing healthy tissue. It improves the fitting accuracy of the restoration during bonding procedures [20].

2. Isolation

The rubber dam acts as barrier and prevents fluid seepage coming from saliva, blood and crevicular area. Moisture Contamination of enamel and dentin surface interferes with adhesion and produce lower bond strengths [21]

3. Caries affected dentin

The caries affected dentin at the cavosurface margin of the preparation should be removed completely for better results.The exposure of adhesive interface of caries affected dentin to oral environment will result in hydrolysis of the resin [14].

4. Immediate dentin sealing

The immediate dentin sealing is a technique which seals the freshly cut dentin (after tooth preparation and before impression taking) with a layer of dental bonding agent . It helps to reduce bacterial contamination, reduce gap formation and to improve bond strength of the final restoration [22]

5. Deep Margin Elevation or cervical margin relocation

The proximal box cervical margin extending sub-gingivally presents a clinical challenge. In such situations it is difficult to have adequate isolation of the operating field and inadequate moisture control results in contamination [23].,Therefore,the box must be repositioned supra-gingivally for simpler clinical procedure by cervical margin relocation to ease the adhesive procedure of restoration and to prevent bond failure [24].

6. Cavity Design optimization

This technique prevents unnecessary removal of sound tooth structure during preparation .It uses flowable composite liner and forms an ideal cavity design [25]. It helps in reducing the stresses within the restored teeth. It provides reinforcement of cavity walls, eliminates undercuts ,saves tooth structure, leveling of the cavity floor, and occlusal relocation of cervical margins [26].

7. Controlled adhesive cementation

Highly filled microhybrid composite can be used for cementation of indirect restoration [25]. The viscosity and flow of composite resin can be altered by the application of heat. The viscosity of the cement can be reduced during with a special ultrasonic or sonic cementation tip[2,3] during positioning of the restoration [27,28].

8. Preexisting composite restorations

The old composite restoration must be in good conditions. These restorations should be checked for any defects. The defective restorations can be repaired or needs complete replacement [29]. The repairs as a result of caries have better prognosis compared with fractured restorations. Repair procedures extend the longevity of restorations and reduces the damaging effect of invasive procedures [30].

9. Presence of contaminants

Intermediate medications, cements, gutta-percha, irrigating solutions, smear layer can be present on the dentin surface and can interfere with the adhesion [10].The removal of the residual root canal sealer to dentin seems to be fundamental for the adhesion process[31]. The studies have shown dentin cleaning using ethanol can obtain high bond-strength values [32].

Material related Factors

1. Self etching adhesives

Self etching adhesive systems have shown reduce hydrolytic degradation , acid base resistant zone beneath hybrid layer and has exhibited bond stability[4].

Self etch adhesive has shown lower bond strengths when used with self-cure and dual-cure resin that have not been light activated. This is because the acid from the acidic primer suppress the basic amines of self-cure composites which is used as catalyst and has a high pH .This leads to incomplete polymerization of the adhesive interface. The areas which can be light-cured ,dual cure composites and light-cure composites have shown comparable bond strengths as they have amine free initiator system [33,34].

2. Etch & rinse adhesives

Etch-and-rinse adhesive systems does not form acid- base resistant zone beneath hybrid layer as is commonly seen in self etch adhesives [35]. The etch and rinse adhesives are prone to biodegradation of the adhesive interface [36]. In etch-and-rinse adhesive systems, the phosphoric acid etching results in deep dentin demineralization and there is incomplete infiltration of monomers till the base of demineralized dentin. The exposed collagen fibers in this demineralised dentin thus becomes more prone to enzymatic degradation. The addition of hydrophilic monomers in the adhesives helps in proper penetration of hydrophobic monomers into the humid dentin. However,the hydrophilic monomers attracts water from dentin matrix and produce water filled channels within the polymeric matrix. Moreover, the resins are leached out creating nanometer-sized voids which is replaced by water within resulting in hydrolytic degradation of the resins within the hybrid layer [36]. Consequently,the activated proteolytic enzymes (MMPs) causes degradation of the exposed collagen fibrils at the bonding interface [4,36]. The biodegradation of adhesive interfaces can be minimized by [4,37]

a. Use of Matrix Metalloproteinase inhibitors
chlorhexidine, ethylene diamine tetraacetic acid (EDTA) and benz alkonium chloride

b. Exogenous Cross linker
It causes biomodification of dentin
Physical Agents: Vit B12 activated by UV light,
Nonspecific Synthetic Agents: Glutaraldehyde, carbodiimide hydrochloride Agents of Natural Origin: Antioxidants substances
Biomimetic Remineralization: Amorphous calcium phosphate nanoprecursors.

c. Ethanol wet bonding
Methacrylates monomers are hydrophobic in nature. These adhesives when used in acid conditioned water-saturated dentin, causes nanophase separation of adhesives. The use of wet ethanol bonding prevents phase separation.
The free water and some bound water can be removed by ethanol .This decreases separation between the collagen matrix and resin monomers. Thus the action of collagenolytic enzymes can be minimised.

d. Hydrophobic Monomers
The more hydrophobic monomers in adhesive provides more stable bonds over time. The ethanol replaces water from dentin and helps in easier penetration of hydrophobic monomers into the dentin forming a stable hybrid layer.

3. Endodontic Irrigants and sealers

Certain endodontic Irrigants and sealers have negative effect on adhesion [38].When dentin is subjected to the action of sodium hypochlorite, EDTA, and chlorhexidine . These irrigants results in irreversible changes in dentin. Studies have shown loss in dentin structural framework , loss of ions,various elements, water, as well as changes in collagen fiber crosslinks. These changes affect the adhesion processes and its subsequent outcomes [39].

Conclusion

Meticulous attention on the various factors related to bonding of resin adhesives to root filled teeth can facilitates the effectiveness of adhesive bond and the long term survival of the teeth. The understanding of these factors is of significance and will help clinicians to provide better treatment outcomes.

REFERENCES

1. Schwartz RS & Fransman R. Adhesive dentistry and endodontics. Materials,clinical strategies and procedures for restoration of access cavities: a review J Endod 2005;31(3):151-165.
2. Sheets CG, Taniguchi T .Advantages and limitations in the use of porcelain veneer restorations..J Prosthet Dent.1990; 64(4):406-11.
3. Montagner AF,Carvalho MPM, and Susin AH. Microshear bonding effectiveness of different dentin regions. Indian J Dent Res.2015;26(2):131–135.
4. Betancourt DE,Baldion PA, Castellanos JE. Resin-Dentin Bonding Interface: Mechanisms of Degradation and Strategies for Stabilization of the Hybrid Layer", Int. J. Biomater.2019, Article ID 5268342, 11 pages. https://doi.org/10.1155/2019/5268342
5. Pegado REF, do Amaral FL, Flório FM, Basting RT. Effect of different bonding strategies on adhesion to deep and superficial permanent dentin. Eur J Dent. 2010;4(2):110-117.
6. Manuja N, Nagpal R. Resin-tooth interfacial morphology and sealing ability of one-step self-etch adhesives: Microleakage and SEM study. Microsc Res Tech 2012;75(7):903-9.
7. Nagpal R, Manuja N, Pandit IK. Adhesive bonding to pulp chamber dentin after different irrigation regimens. J Investig Clin Dent 2015;6(4):287-93.
8. Schellenberg U, Krey G, Bosshardt D, Nair PN. Numerical density of dentinal tubules at the pulpal wall of human permanent premolars and third molars. J Endod 1992;18(3):104-9.
9. Nagpal R,Singh P,Singh S,Manuja N,Gupta R,Sharma P.Adhesion to pulp chamber dentin.Effect of different endodontic irrigants. J Res Dent 2016;4(2):53-8
10. Özcan M, Volpato CAM. Current perspectives on dental adhesion: (3) Adhesion to intraradicular dentin: Concepts and applications. Jpn Dent Sci Rev. 2020; 56(1):216-223
11. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, Mjör IA. Bonding to root canal: structural characteristics of the substrate.Am J Dent 2000; 13(5):255-260
12. Breschi L,Mazzoni A, Ruggeri A, Cadenaro M, DiLenarda R,Dorigo EDS Dental adhesion review: aging and stability of the bonded interface.Dent Mater 2008;24(1): 90-101
13. Helfer AR, Melnick S, Schilder H. Determination of the moisture content of vital and pulpless teeth. Oral Surg Oral Med Oral Pathol 1972 :34(4):661-70
14. Nakajima M ,Kunawarote S,Prasansuttiporn T ,Tagami J. Bonding to caries-affected dentin Jpn Dent Sci Rev. 2011; 47(2): 102-114
15. Tjäderhane L, Nascimento FD, Breschi L, Mazzoni A, Tersariol IL, Geraldeli S, Tezvergil-Mutluay A, Carrilho MR, Carvalho RM, Tay FR, Pashley DH. Optimizing dentin bond durability: control of collagen degradation by matrix metalloproteinases and cysteine cathepsins.Dent Mater. 2013; 29(1):116-35
16. Spencer P, Wang Y, Katz JL, Misra A. Physicochemical interactions at the dentin/adhesive interface using FTIR chemical imaging J Biomed Opt 2005; 10(3):031104
17. NakajimaM, Sano H,BurrowMF, TagamiJ, YoshiyamaM, Ebisu S, Ciucchi B, Russel CM,,Pashley DH.Tensile bond strength and SEM evaluation of caries-affected dentin using dentin adhesives.J Dent Res 1995;74 (10):1679-1688.
18. Wang J, Song W, Zhu L. et al. A comparative study of the microtensile bond strength and microstructural differences between sclerotic and Normal dentine after surface pretreatment. BMC Oral Health 2019 : Article no 216
19. Tay FR.Pashley DH. Resin bonding to cervical sclerotic dentin : A review. J Dent.2004;32(3):173-196
20. Carvalho MA, Lazari PC, Gresnigt M,Del Bel Cury AA,Magne P. Current options concerning the endodontically-treated teeth restoration with the adhesive approach. Braz Oral Res 2018;32(suppl1):e74.
21. Polesel A. Restoration of the endodontically treated posterior tooth. Giornale Italiandi Endodonzia 2014; 28(1):2-16

22. Magne P. Immediate Dentin Sealing: A Fundamental Procedure for Indirect Bonded Restorations . J Esthet Restor Dent 2005;17(3):144–154.
23. W. Keys, S.J. Carson Rubber dam may increase the survival time of dental restorations Evid Based Dent, 18 (2017), pp. 19-20 .
24. Magne, P. and Spreafico, R.C. "Deep margin elevation: A paradigm shift." Am J Esthet Dent 2012; 2: 86-96
25. Blatz MB. Bonding Protocols for Improved Long-Term Clinical Success Compend Contin Educ Dent2014;35(4):276-7.
26. Shi L, Fok, ASL & Qualtrough, A. A two-stage shape optimization process for cavity preparation. Dent Mater 2008;24(11):1444–1453.
27. Peutzfeldt A. Effect of the ultrasonic insertion technique on the seating of composite inlays. Acta Odontol Scand.1994;52:51–54.
28. Schmidlin PR, Zehnder M, Schlup-Mityko C, Göhring TN. Interface evaluation after manual and ultrasonic insertion of standardized class I inlays using composite resin materials of different viscosity Acta Odontol Scand 2005;63(4):205- 212.
29. Blum IR,Jagger DC,Wilson NHF. Defective dental restorations: To repair or not to repair?Part 1: Direct composite restorations Dent Update 2011; 38: 78–84.
30. Sarrett DC. Clinical challenges and the relevance of materials testing for posterior composite restorations. Dent Mater 2005; 21: 9–20.
31. Kuga MC, Faria G, Rossi MA, do Carmo Monteiro JC et al. Persistence of epoxy-based sealer residues in dentin treated with different chemical removal protocols. Scanning. 2013;35(1):17-21.
32. Bronzato JD, Cecchin D, Miyagaki DC, de Almeida JA, Ferraz CC. Effect of cleaning methods on bond strength of self-etching adhesive to dentin. J Conserv Dent 2016;19(1):26-30.
33. Schwartz RS.Adhesive dentistry and endodontics.Part 2 Bonding in the root canal system-the promise and problems:A review.J Endod 2006;32(12):1125-1134.
34. Foxton RM, Nakajima M, Tagami J, Miura H. Bonding of photo and dual-cure adhesives to root canal dentin. Oper Dent 2003;28:543–51.
35. Inoue G, Nikaido T, Foxton RM, Tagami J.The Acid- Base resistant zone in three bonding systems.Dent Mater J. 2009:28(6):717-721.
36. Matos AB, Trevelin LT, Silva BTF, Francisconi-dos-Rios LF, Siriani LK, Cardoso MV.Bonding efficiency and durability: current possibilities. Braz. Oral Res. 2017;31(suppl):e57.
37. Moraes IQS de, Nascimento TG do, Silva AT da, Lira LMSS de, Parolia A, Porto ICCM. Inhibition of matrix metalloproteinases: a troubleshooting for dentin adhesion. Restor dent endod. 2020;45(3):e31.
38. Cecchin D, Farina AP, Barbizam JVB,Paranhos MPG,Carlini B..Effect of endodontic irrigating solutions on the adhesive bond strength to dentin. Rev Odonto Cienc 2011;26(4):341-345.
39. Torres-Reyes LM ,Torres-Rodríguez C. Characterization of endodontically treated dentin. Revista Facultad de Odontología Universidad de Antioquia,2014; 25(2), 372-388.